Digital Engineering Benefits Study

Sponsor: OUSD(R&E)

Presented to
INCOSE MBSE Workshop, January 26, 2020
Tom McDermott

www.sercuarc.org

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Enterprise Modeling of the DoD Digital Information Exchange Process

- 2018: SERC Project RT-182 conceptually modeled the 5 goals of the DoD DE Strategy to identify necessary acquisition enterprise changes

- 2019: Addressing multiple OUSD/RE research priorities:
  - DE Metrics (WRT-1001), determine critical ROI measures and improved SE value indicators
  - Model Curation (WRT-1009), curation practices, enablers, and technical innovation opportunities
  - DE Workforce (WRT-1006), DE competency model for DAU

Presented at inaugural DEIXWG meeting, INCOSE IS2018
SERC WRT-1001 Digital Engineering Metrics
Project Guiding Questions

• If you had a “Program Office Guide to Successful DE Transition” what would that look like?
  — Extend previous SERC work on DE enterprise transformation to the program office level.

• How can the value and effectiveness of DE be described and measured?
  — Determine appropriate metrics for evaluating the benefits of DE transformation.

• Are there game-changing methods and/or technologies that would make a difference?
  — Analyze the DE Innovation System (methods, processes, and tools) to identify gaps and challenges and potential paths for innovation.

• Can we describe an organizational performance model for DE transformation?
  — Generalize the data and results.
SERC WRT-1001 DE Metrics Project Activities

**Horizon Scanning**
- Digital Business Trends
- DevOps trends
- Technologies & Metrics

**Innovation System Analysis**
- Problem Space definition
- Innovation Areas
- Innovation Enablers/Barriers

**RT-182 Results**
- Initial enterprise transition model
- Acquisition Outcomes Focus
- Candidate Metrics

**Literature Review**
- Published DE/MBSE value -> benefit -> gain
- Candidate Metrics

**DE/MBSE Maturity Survey**
- Assessment of relative maturity -> value -> benefits
- Candidate Metrics

**Workshops**
- DoD Program Office Focus
- Industry Sample
- Evaluation of Metrics

**Program Success Guidance**

**Enterprise Performance Analysis**
Categorizing DE Success Measures

Quality:
- Defects/Design Escapes
- AoA coverage
- Design space explored
- SE rigor
- CM

Knowledge Transfer:
- Data/Model reuse
- Link to Mission Eng
- Depth of review
- Expanded Visualization
- Innovation

User Experience:
- Collaboration
- Automation
- Interoperability

Adoption:
- Pace of adoption
- Infrastructure investment
- Enterprise process & tool integration
- Tool/model interoperability
- Role/Skill transition

Models are used to inform enterprise and program decision making
An enduring, authoritative source of truth is used over the lifecycle
Use technological innovation to improve engineering practices
Infrastructure and environments support improved communication and collaboration
Transform culture and workforce engineering across the lifecycle

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Results
Preliminary Literature Review Results

• Searched papers that mention a benefit of MBSE and what the source of that benefit was: measured gains, observed gains, perceived gains (no source for benefit), reference.

  – Total Papers that mention MBSE: 847
    o Papers that mention benefits: 360
      – Measured gains: 2
      – Observed gains: 36
      – Perceived gains: 240
      – Reference: 108
      – Misc.: 4

*Kaitlin Henderson (VT) PhD studies
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<th>Category</th>
<th>Perceived</th>
<th>Observed</th>
<th>Measured</th>
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<td>Reduce Errors (16)</td>
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<td>&gt; System Quality (1)</td>
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<td>Reduce Risk (2)</td>
<td>Reduce Risk (1)</td>
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<td>Rigor (6)</td>
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<td>Reduce Cost (33)</td>
<td>Reduce Cost (4)</td>
<td>Reduce Cost (0)</td>
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<td>Velocity/Agility</td>
<td>Consistency (44)</td>
<td>Consistency (6)</td>
<td>Consistency (1)</td>
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<td>Reuse (37)</td>
<td>Reuse (5)</td>
<td>Reuse (1)</td>
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<td>Reduce Time (24)</td>
<td>Reduce Time (8)</td>
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<td>User Experience</td>
<td>Automation (5)</td>
<td>Automation (0)</td>
<td>Automation (2)</td>
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<td>&lt; SE Task Burden (1)</td>
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<td>Manage Complexity</td>
<td>Manage Complexity (2)</td>
<td>Manage Complexity (0)</td>
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<tr>
<td>System Understanding</td>
<td>System Understanding (2)</td>
<td>System Understanding (0)</td>
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<tr>
<td>Knowledge Transfer</td>
<td>Information Access (27)</td>
<td>Information Access (5)</td>
<td>Information Access (2)</td>
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<td>Knowledge Capture</td>
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<td>Knowledge Capture (2)</td>
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<td>Architecture (4)</td>
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<td>Adoption</td>
<td>Comm/Info Sharing (68)</td>
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SSRR 2019
November 19, 2019
7
## MBSE Benchmarking Survey

### Objective
- Assess **value and effectiveness** of MBSE adoption for improving business outcomes (gov’t, industry) – benefits vs. traditional methods. Develop a profile of MBSE use and meeting expectations across the life cycle.
- Where are we as organizations, and as an industry? Building models, or using models? Applying what we learn.
- Enable adopters to conduct a qualitative or quantitative assessment of their progress against MBSE best practices and guidance on developing an improvement roadmap.

### Method
- Conduct an industry survey of MBSE capability. Align with INCOSE draft DE Capabilities Definition matrix.
- Characterizing MBSE practices, capability, value, benefits.
- Probe alignment and integration with other adopter initiatives (e.g., PLM, DevOps, cross-discipline)
- Collect and share best practices and assets on MBSE benefits/value from community.

### Organizational Involvement
- Participation call through industry associations: INCOSE (lead), NDIA, ...
- Government sponsorship and support: DoD (OUSD R&E), FFRDCs (SERC)
- Survey administration by DoD SERC (Stevens Institute) - “honest broker” to protect proprietary data.

### Schedule
- **Survey: Closes February 1, 2020**

### Core Team
- INCOSE: Garry Roedler; Troy Peterson
- NDIA: M&S Committee (Chris Schreiber); SE Division (Joe Elm, Geoff Draper; Garry Roedler)
- SERC: Tom McDermott, Nicole Hutchinson
# MBSE Survey Overview

## Topics

<table>
<thead>
<tr>
<th>Topics</th>
<th>Summary of Survey Questions</th>
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<tbody>
<tr>
<td><strong>1. MBSE Usage</strong></td>
<td>1. MBSE strategy documented at enterprise level</td>
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<td>2. MBSE processes &amp; tools integrated, inform enterprise staff</td>
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<td></td>
<td>3. Q: Primary value of cross-functional MBSE integration?</td>
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<td><strong>2. Model Management</strong></td>
<td>4. Taxonomy for modeling across organization</td>
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<td>5. Well-defined processes/tools for model management.</td>
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<td>6. Standard org guidance for model management/tools</td>
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<td>7. Q: Business value from consistent model management?</td>
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<td><strong>3. Technical Management</strong></td>
<td>8. Modeling basis for enterprise org processes</td>
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<td>9. MBSE process support for technical reviews</td>
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<td>10. Q: Value of MBSE (or digital engrg) in technical reviews?</td>
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<tr>
<td><strong>4. Metrics</strong></td>
<td>11. Modeling provides measurable improvement across projects</td>
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<td>12. Consistent metrics across programs/enterprise?</td>
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<td>13. Q: Most useful metrics?</td>
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<tr>
<td><strong>5. Model Quality</strong></td>
<td>14. Defined processes/tools for V&amp;V of models</td>
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<td>15. Defined processes/tools for data/model quality assurance</td>
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<td><strong>6. Data Management</strong></td>
<td>16. Org approach for data interface between tools</td>
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<td>17. Data managed independent of tools for portability</td>
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<td></td>
<td>18. Q: Data management roles/processes?</td>
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<td><strong>7. Model Sharing and Reuse</strong></td>
<td>19. Teams establish, share, reuse org model libraries</td>
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<td>20. Org interface around models for stakeholder use</td>
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<td></td>
<td>21. Shared models used to consistently manage programs across lifecycle</td>
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<td></td>
<td>22. Q: org implementation for data/model discovery, reuse?</td>
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<td><strong>8. Modeling Environments</strong></td>
<td>23. Modeling environment security</td>
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<td>24. Modeling environment protects IP</td>
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<td>25. Cross-discipline processes for tools, data interoperability</td>
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<td>26. Q: value from collaborating on models across disciplines</td>
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<td><strong>9. Organizational Implementation</strong></td>
<td>27. Q: most challenging org obstacles for MBSE?</td>
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<td>28. Q: Best organizational enablers for MBSE?</td>
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<td></td>
<td>29. Q: Biggest changes our org needs for MBSE?</td>
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<tr>
<td><strong>10. Workforce</strong></td>
<td>30. Organization defined critical roles to support MBSE</td>
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<td></td>
<td>31. Q: Top MBSE roles in your organization?</td>
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<td></td>
<td>32. Org staffing adequate to fill MBSE-related roles?</td>
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<td><strong>11. MBSE Skills</strong></td>
<td>33. Defined critical skills for MBSE</td>
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<td>34. Q: The most critical skills for MBSE?</td>
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<tr>
<td><strong>12. Demographics</strong></td>
<td>Organizational size, domain, MBSE experience</td>
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Survey content is derived from the draft INCOSE Digital Engineering Capabilities Definition
mbsematuritysurvey.sercuarc.org

Survey data as of January 22, 2020.
Survey will close on February 1.
Interim Results: Demographics

My organization is in:

- Government: 45
- Industry: 101
- Academia: 11
- Not Answered: 3

Keywords:

- Agriculture
- Aeronautical Services
- Building
- Government/DoD
- Equipment
- Intelligence
- Management
- NASA
- Agrigenomic Division
- Navy
- Military
- DoD
- Automotive
- Aerospace
- Health Security
- System Educating
- Fortune
- Industrial
- Genomics
- Advices
- Defense
- Small
- Space
- Food
- Technical
- Size
- Transport
- Consulting
- R&D
- Non-DOD
-小さ
- China
- System
- Scientific
- Aeronautics
- Undersea
- Defence/Aerospace
- Construction
- Military
- Infrastructure
- Rail
- Consultancy
- Scientific
- Environment
- DOE
- Electronics
- Medical
- Manufacturing
- Consulting
- Forestry
- Airplane
- Industry
- Contracting
- Government
- User
- Simulation
- Accession
- Software
- Device
- Software
- Avionics
- Software
- Military
- Military
- Defense
- Industry
- Government
Interim Results: Demographics

Organization Size:

How long has your organization been working toward MBSE:

My primary role in my organization is:

- Executive management
- Systems Engineer
- Information Technology professionals
- Other Engineering or Software disciplines
- Modeling and Simulation
- Acquisition professional
- Other
- Not Answered
**Interim Results: MBSE Usage**

**MBSE USAGE**
Our MBSE use strategy is integrated with our overall product strategy or strategies at the enterprise level.

Agree rate: 2.425

**MBSE USAGE**
Our MBSE processes and tools are integrated with our overall product-level processes and tools.

Agree rate: 2.312

**MBSE USAGE**
What do you see as the most important reasons for integrating MBSE processes with program and business management processes?

Answered: 159

Not Answered: 68
Interim Results: Model Management

As part of our MBSE process, we have a clear taxonomy that we use consistently for modeling across our organization.

Agree rate: 2.258

Our organization has well-defined processes and tools for managing models across a program lifecycle.

Agree rate: 2.226

Our organization has standard business and program guidance that defines our model management processes and tools.

Agree rate: 2.248
Interim Results: Technical Management

**TECHNICAL MANAGEMENT**

Our organization uses modeling as the basis for our technical processes consistently across the enterprise.

Agree rate: 2.165

**TECHNICAL MANAGEMENT**

Our MBSE process fully supports our technical review process.

Agree rate: 2.28

**TECHNICAL MANAGEMENT**

Please identify any benefits or challenges your organization has found in the use of MBSE (or 'digital engineering') in the technical review process.

Answered: 111
Interim Results: Metrics

**METRICS**

Modeling activities in our organization provide measurable improvements within and across projects.

Agree rate: 2.612

**METRICS**

We have consistent metrics across our program(s)/enterprise that include our modeling activities.

Agree rate: 2.093

Answered: 92
Interim Results: Model Quality

MODEL QUALITY

Our organization has defined processes and tools for verification and validation of models at appropriate levels and program phases.

Agree rate: 2.329

MODEL QUALITY

Our organization has defined processes and tools for data and model quality assurance.

Agree rate: 2.292
Interim Results: Data Management

New data management roles & processes:

- Chief data and analytics role
- Program Data & Information Architects
- Digital Environment working group
- Data analytics group
- Enterprise tool integration
- IT data store management
- Special database
- V&V of the data
- Stewardship of the data, curator
- TBD but clear it must be architected
- Tool interoperability is an issue
- Need common intermediate data formats
- Concern about data lifecycles
- Industry standards are limiting
Interim Results: Model Sharing & Reuse

MODEL SHARING AND REUSE
Our organization supports model libraries for the purpose of model reuse.
Agree rate: 2.544

MODEL SHARING AND REUSE
Our organization has implemented an interface around our models that can be used and understood by a variety of stakeholders.
Agree rate: 2.273

MODEL SHARING AND REUSE
Shared models are being used to consistently manage systems across the lifecycle.
Agree rate: 2.211
Interim Results: Modeling Environment

MODELING ENVIRONMENT

Our organization takes steps to make sure our modeling environment is secure.

Agree rate: 3.214

MODELING ENVIRONMENT

Our organization takes steps to make sure that our modeling environment protects our intellectual property.

Agree rate: 3.082

MODELING ENVIRONMENT

Our organization has defined processes and work instructions that cover tool selection, use, and related data interoperability concerns.

Agree rate: 2.475
Interim Results: Obstacles & Enablers

MODELING ENVIRONMENT

Please identify any additional benefits you find from collaborating on models across disciplines.

Answered: 79

ORGANIZATIONAL IMPLEMENTATION

The most challenging obstacles to implementing MBSE in our organization are:

Answered: 158

ORGANIZATIONAL IMPLEMENTATION

The best enablers to MBSE in our organization are:

Answered: 149

ORGANIZATIONAL IMPLEMENTATION

Going forward, the biggest changes our organization needs to make to improve our implementation of MBSE are:

Answered: 144
Our organization has clearly defined the critical roles to support MBSE.

Agree rate: 2.306

We have sufficient staffing in our organization to fill all MBSE-related roles.

Agree rate: 2.019
Interim Results: Workforce

The most critical skills for MBSE are:
- Knowledge of systems engineering processes
- Understanding of systems architecture
- Business architecting, architecture frameworks
- Domain knowledge
- Knowing SysML and operation of modeling tools
- Process management & development
- MBSE "super users"
- Combined SE/MBSE expertise
- Operational modeling
- Informed program management
- Information architecture
- IT/server/cloud management & support
- Requirements Management & tracing
- Report generation
- Collaborative mindset
- Systems & critical thinking
- Analytical thinking/parametric modeling
- Software/programming skills
- Data scientist
- Ontologies
- Customer communication
- Experience
- Interdisciplinarity
SERC WRT-1001 DE Metrics Project Activities

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Program Success Guidance

Enterprise Performance Analysis
Adapting the Baldrige Framework to DE Transformation

- The Baldrige Criteria for Performance Excellence (CPE) provide a comprehensive framework of organizational sub-systems
- Used for recognition (the national Baldrige Award), assessment & diagnosis of organizational and process maturity, and to guide large-scale transformation (e.g., to pay attention to all key sub-systems during transformation)

http://www.nist.gov/baldrige

For example:
- Leaders communicate clear reason for MBSE adoption
- MBSE aligned with overall organizational strategy
- Workforce have needed skills to support MBSE use
- Data management processes support MBSE
- Organizational culture aligned with MBSE use
- Clear metrics defined to track results and progress
- MBSE adoption aligned with what customers need
Questions?

Thank you!